Advancements in the Representation of Cloud-Aerosol Microphysics in the GEOS-5 AGCM

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Despite numerous challenges, the physical parameterization of cloud-aerosol interactions in atmospheric GCMs has become a top priority for advancement because of our need to simulate and understand past, current, and future indirect effects of aerosols on clouds. The challenges stem from the involvement of wide range of cloud-scale dynamics and aerosol activation physical processes. Cloud dynamics modulate cloud areal extent and condensate, while aerosol activation depends on aerosol mass load, size distribution, internal mixing state, and nucleating properties, and ultimately determines cloud optical properties via particle sizes. Both macro- and micro-scale processes are obviously important for cloud-radiation interactions.

We will present the main features of cloud microphysical properties in the GEOS-5 Atmospheric GCM (AGCM) as simulated by the McRAS-AC (Microphysics of Clouds with Relaxed Arakawa-Schubert and Aerosol-Cloud interaction) scheme. McRAS-AC uses Fountoukis and Nenes (2005) aerosol activation for liquid clouds, and has an option for either Liu and Penner (2005) or Barahona and Nenes (2008, 2009) aerosol activation for ice clouds. Aerosol loading (on-line or climatological) comes from GOCART, with an assumed log-normal size distribution. Other features of McRAS-AC are level-by-level cloud-scale thermodynamics, and Seifert-Beheng (2001)-type precipitation microphysics, particularly from moist convection. Results from Single-Column Model simulations will be shown to demonstrate how cloud radiative properties, lifetimes, and precipitation are influenced by different parameterization assumptions. Corresponding fields from year-long simulations of the full AGCM will also be presented with geographical distributions of cloud effective particle sizes compared to satellite retrievals. While the primary emphasis will be on current climate, simulation results with perturbed aerosol loadings will also be shown to expose the radiative sensitivity of the microphysical parameterization.